DRAFT

SURFACE HYDROLOGY INVESTIGATIONS

EXISTING DATA REVIEW
SPRING RIVER WATERSHED
TECHNICAL MEMORANDUM
102-7L37/W68540

Cherokee County Site
December 24, 1986

Engineers
Planners
Economists
Scientists

December 24, 1986

W68540.ED

Ms. Alice Fuerst
Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Fuerst:

Enclosed for your review is the Draft Technical Memorandum on "Existing Surface Water Hydrology Data" for the Cherokee County Site. I am sending two copies at this time, but please call if you need more. The Technical Memorandum on the low flow hydrology investigation in September 1986 will be sent by the end of the month.

Sincerely,

Richard Moos

Richard Moos, Ph.D
SM, Cherokee County Site

DE/CC2/057/mf
cc: Gale Wright, EPA Region VII
Bob Ogg, APM-OPNS, CH2M HILL, WDC
Mike Thompson, RM, CH2M HILL, KCK
Bill Bluck, RTL, CH2M HILL, SLC
Emory McLean, SRW Associates

SUMMARY

The existing water quality and flow data base is useful to establish the general trends of selected parameters in and around the study area. All of the long-term USGS flow gaging stations are outside the site boundaries (refer to Figure 1 in the technical memorandum). Therefore, site-specific flow information (stream gaging) continues to be a priority component of the work plan to develop a range of alternative remedial actions and ultimately a record of decision (possible on a subsite basis). Also, the existing flow data do not permit determination of the contributions of specific watersheds to Spring River flows.

Some specific water quality data are available for tributaries within the Cherokee County study area. These data are useful for setting the historic pattern of some tributary contributions but, like the flow data, are not sufficiently complete to allow definition of remedial alternatives for a comprehensive or operable unit feasibility study. Primary deficiencies include:

- Incomplete suite of relevant parameters in the water quality data base
- Lack of site-specific data for the main tributaries to Spring River (i.e., Short, Turkey, Cow, Willow, and Shoal Creek, etc.); lack of subsite specific data such as Short Creek and its tributaries; and limited data on the Spring River near Baxter Springs, Galena, and Empire Lake
- Lack of data continuity over different seasons, flow regimes, and between critical locations

The existing data are useful for establishing background conditions inside and outside the study area and for furnishing limited, site-specific data within the study area. The USGS Open-File Report 84-439, "Assessment of Water Resources in Lead-Zinc Mined Areas in Cherokee County, Kansas, and Adjacent Areas (1984)," is the only study specifically addressing this problem within the study area. It has a regional focus and has limited use in determining site-specific remedial measures.

The project staff will continue to investigate some existing data sets to determine what portions of the data set could be used for RI or FS tasks, to determine exact sampling locations if necessary, and to acquire more information on the analytical and quality control methodology for those data sets that are used in future tasks.

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INTRODUCTION

This Technical Memorandum was prepared to partially fulfill the requirements under the Interim Work Plan Memorandum of November 3, 1986, for EPA WA No. 102-7L37. The work assignment was issued by EPA to CH2M HILL to perform the Remedial Investigation and Feasibility Study (RI/FS) for the Cherokee County Site, Kansas.

The purpose of this technical memorandum is to report and summarize the existing water quality and flow data from various sources for the watersheds in and around the Cherokee County Site, and to determine if these data are applicable and usable for the RI/FS.

Specific objectives of the review and analysis of existing data were:

- Acquire or calculate the surface area for each of the watersheds of interest for the project.
- Obtain historical flow data for the Spring River and major tributaries (if possible) and describe annual and seasonal flows.
- Prepare hydrographs for the Spring River and major tributaries (if possible) over appropriate periods of record.
- Review readily available flow and water quality data from STORET and see if there are relationships between precipitation and runoff, and between flow rates and water quality.
- Review flow relationships between the Spring River and major tributaries if data is available.
- Prepare a technical memorandum summarizing the results of this task.

A separate technical memorandum is being prepared to discuss the surface hydrology/water quality data collected for this project in September 1986.

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WATERSHED AREAS

The contributory drainage area to each of the waterways of interest was determined from U.S. Geologic Survey (USGS) 7.5-minute quadrangle maps and information obtained from the USGS stream gaging stations. The drainage areas for each stream are listed in Table 1. The drainage areas upstream of the two stream flow gaging stations located on the Spring River were obtained from the station data. The drainage areas of the remaining watersheds were measured from the mouth of the main drainageway.

Table 1
WATERSHED DRAINAGE AREAS

Stream	Drainage area (mi^2)
Spring River at Waco, MO (USGS Gage No. 07186000)	1164
Spring River at Quapaw, OK (USGS Gage No. 0788000)	2510
Cow Creek	224
Center Creek	302
Turkey Creek	46
Shawnee Creek	63
Short Creek	18
Spring Branch	3.2
Tributary A to Short Creek	0.2
Tributary B to Short Creek	2.4
Tributary C on Spring River	4.5
Unnamed tributary to Shoal Creek	1.1
Willow Creek	14
Brush Creek	55

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HISTORICAL FLOW DATA

Historical flow data were obtained from the USGS for the following stream flow gaging stations for the time periods indicated:

o	Spring River at Waco, MO	1950 to 1985
o	Center Creek near Carterville, MO	1963 to 1985
o	Turkey Creek near Joplin, MO	1964 to 1972
o	Shoal Creek above Joplin, MO	1942 to 1984
o	Spring River near Quapaw, OK	1940 to 1985

The locations of the gaging stations are shown in Figure 1. All the stations are located outside the Cherokee County study area. No long-term flow data were found for locations within the study area. However, the Spring River gaging station at Waco provides a good record of the flow and water quality entering the site. The Spring River gage near Quapaw provides a record for flow and water quality at the downstream end of the site. The Spring River is presumed to be a major transport pathway for dissolved and total metals.

Figure 2 presents the yearly flow duration curves developed from the periods of record at the two Spring River gaging stations. These curves show the magnitude and duration of stream flow recorded at the stations and indicate the contribution of flow to the Spring River between Waco, Missouri, and Quapaw, Oklahoma. The curves also indicate that the flow in the Spring River is perennial. The lowest flow recorded was 4.2 cfs at the upper gage and 5.8 cfs at the lower one. The lower flows are indicative of the local tributaries and their base flows (mostly groundwater contribution) to the river. Table 2 gives average information for both gages for their respective period of record.

Table 2
SPRING RIVER GAGING DATA
FOR WACO, MISSOURI, AND QUAPAW, OKLAHOMA GAGES

Measurement	Waco, Missouri (Gage No. 07186000)	Quapaw, Oklahoma (Gage No. 07188000)
Average Discharge (cfs)	853	1,929
Average Runoff (inches/year)	9.95	10.44
Average Volume (acre-feet/year)	618,000	1,398,000

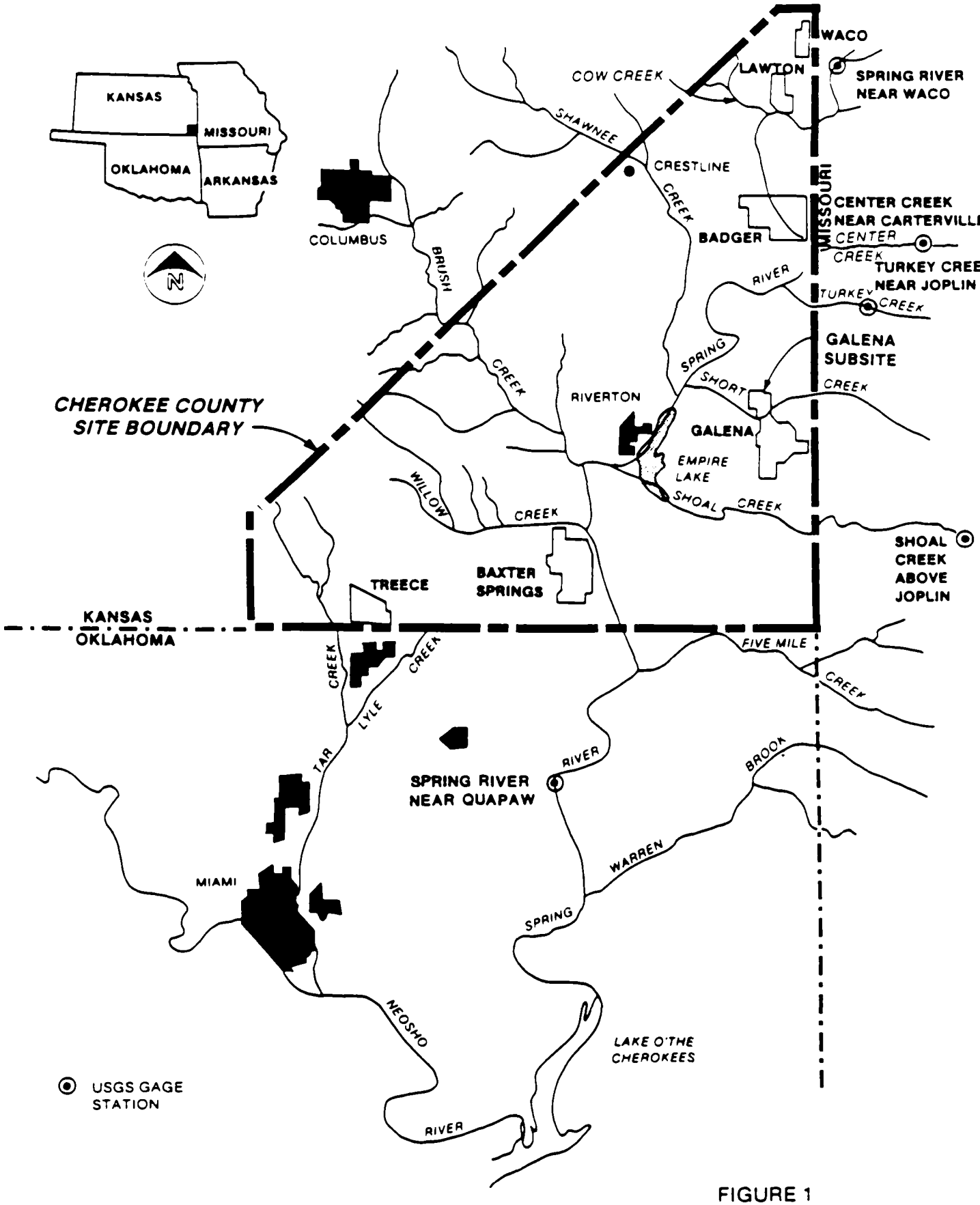

FIGURE 1
LOCATIONS OF SUBSITES AND USGS GAGE STATIONS
CHEROKEE COUNTY SITE

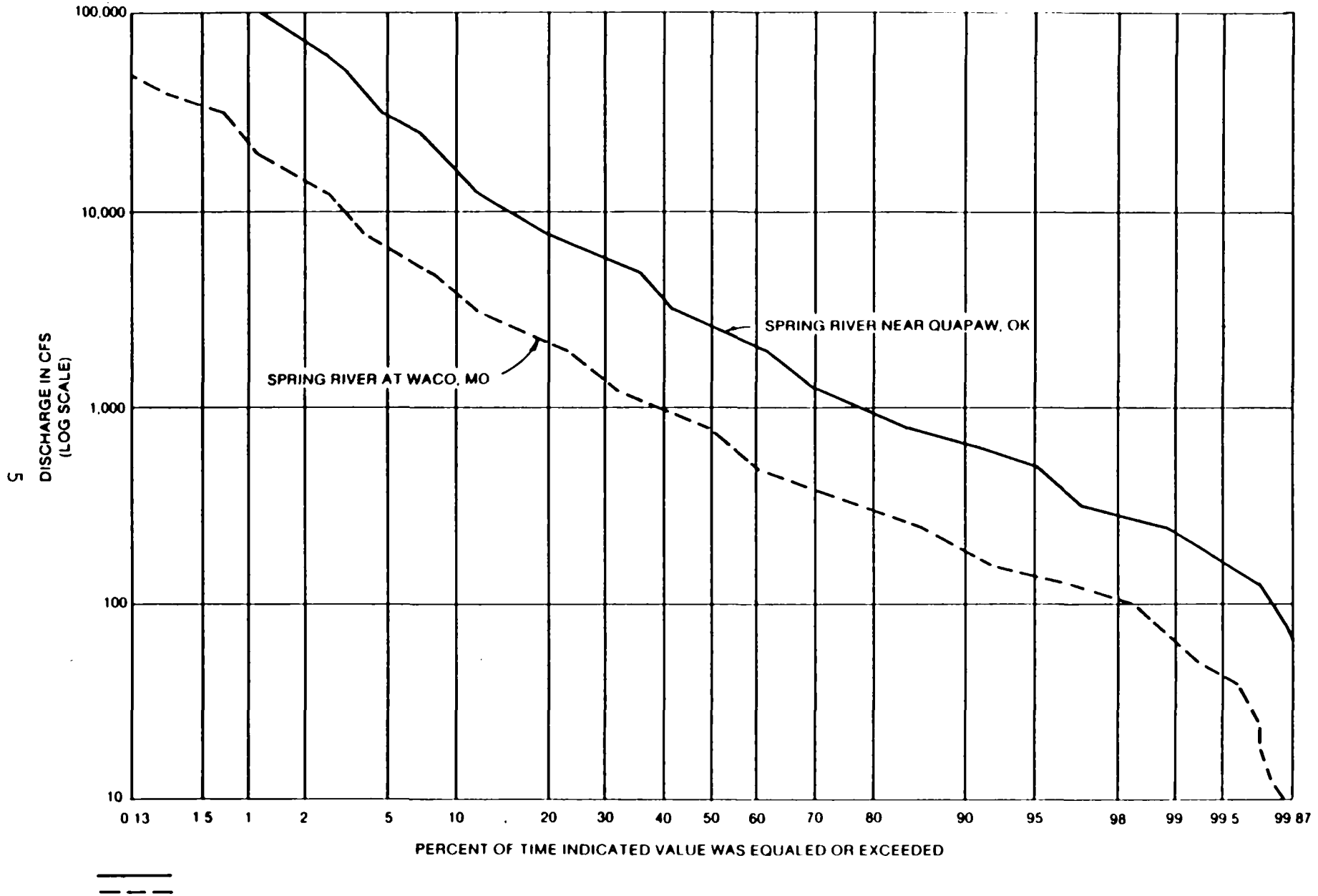

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FIGURE 2
FLOW DURATION CURVE
CHEROKEE COUNTY SITE

The drainage area between the gages is 1,346 square miles and includes lands inside and outside the Cherokee County site boundary. Based on the data in Table 2, the mean annual runoff for the tributary drainage area between the gages is 10.86 inches per year. This value is nearly 10 percent greater than the upstream drainage and results in a 5-percent increase in unit runoff at the lower gage. Tributaries of interest in this study total slightly over 733 square miles of area or 54 percent of the drainage area between the two USGS gages on the main stem of the Spring River.

Figure 3 shows the average yearly flows at each of the two Spring River gaging stations. This graph indicates the general trends in total runoff associated with wet and dry periods for this watershed. It also shows the contribution of flow to the Spring River between the stations. The maximum recorded flows over the period of record at the two stations are 103,000 cfs at the Waco station and 190,000 cfs at the Quapaw station, both recorded on May 19, 1973.

Average monthly volumes of runoff past each of the five gaging stations are shown in Figure 4. This figure was developed from the flows recorded at each station for the respective periods of record. It shows the seasonal variation in flow past each station and the increase in total runoff associated with increasing drainage areas.

Figure 5 presents the specific volume of runoff past each of the stations for a common period of record for the five stations (1964 to 1972). The differences in the degree of infiltration occurring in each of the watersheds can be ascertained, assuming the total amount of rainfall over the 8-year period is equal in all the basins. The degree of infiltration in a drainage basin is dependent on antecedent moisture in the soil, the type of land surface, the land surface treatment, the type of soil material, and topography. Rainfall that does not run off a site will infiltrate into the soil where it will be returned to the air by evapotranspiration, will be held in the soil, or will percolate into the groundwater and eventually be transported to a drainageway.

FIGURE 3

HISTORIC AVERAGE YEARLY FLOWS

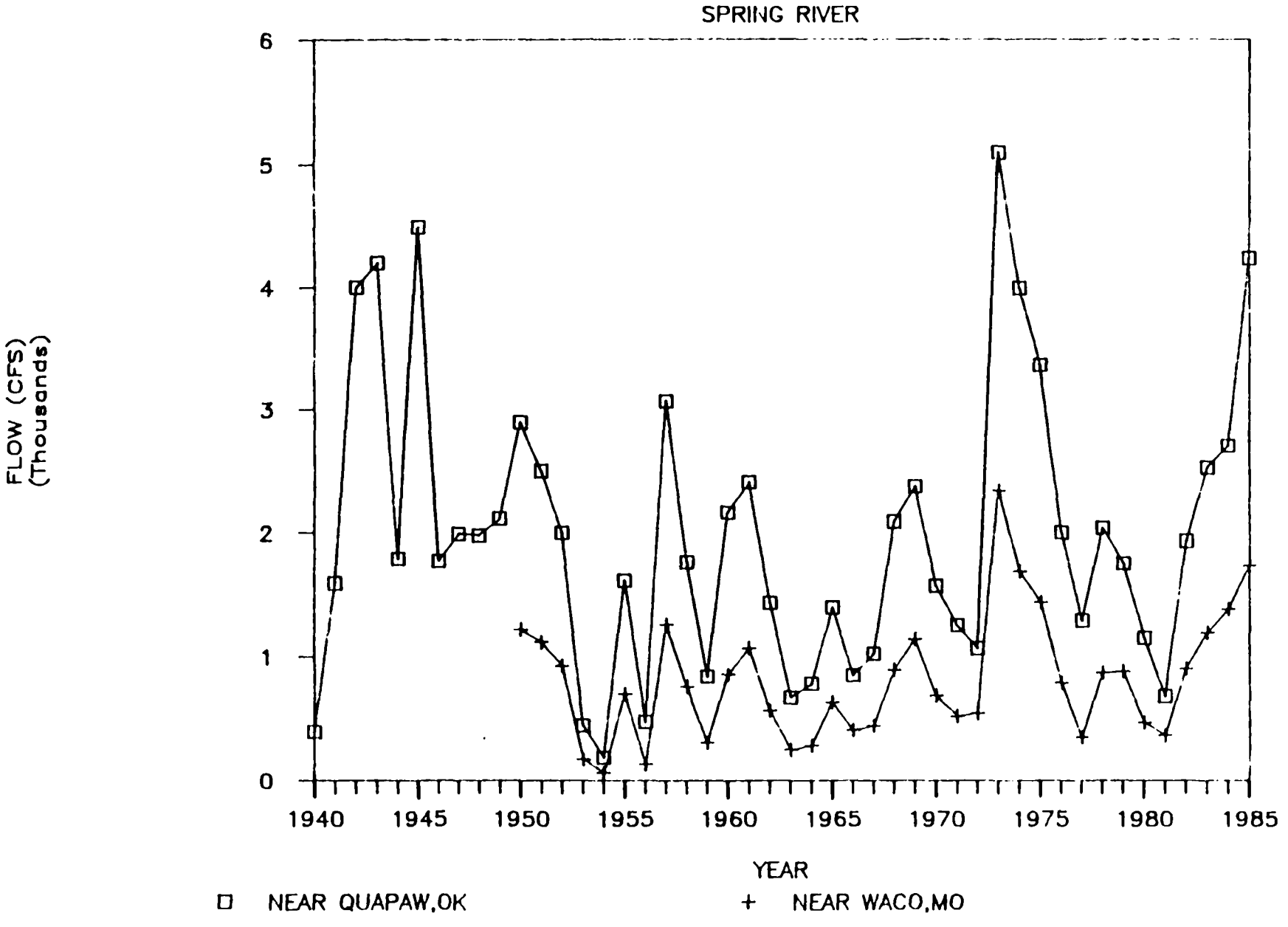

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FIGURE 4

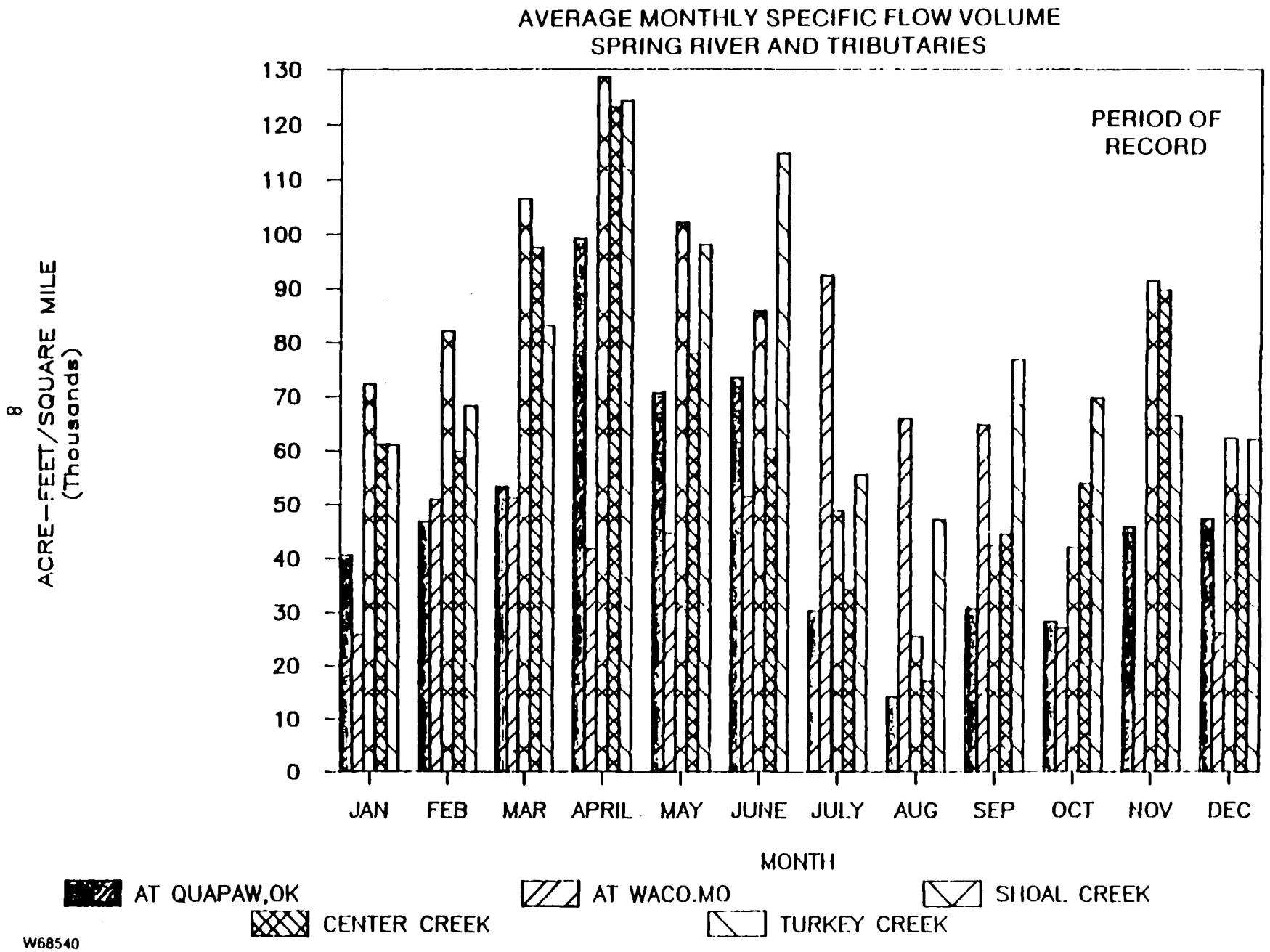
AVERAGE MONTHLY SPECIFIC FLOW VOLUME
SPRING RIVER AND TRIBUTARIES
PERIOD OF RECORD
ACRE-FEET/SQUARE MILE (Thousands)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC
MONTH
AT QUAPAW,OK
AT WACO,MO
SHOAL CREEK
CENTER CREEK
TURKEY CREEK
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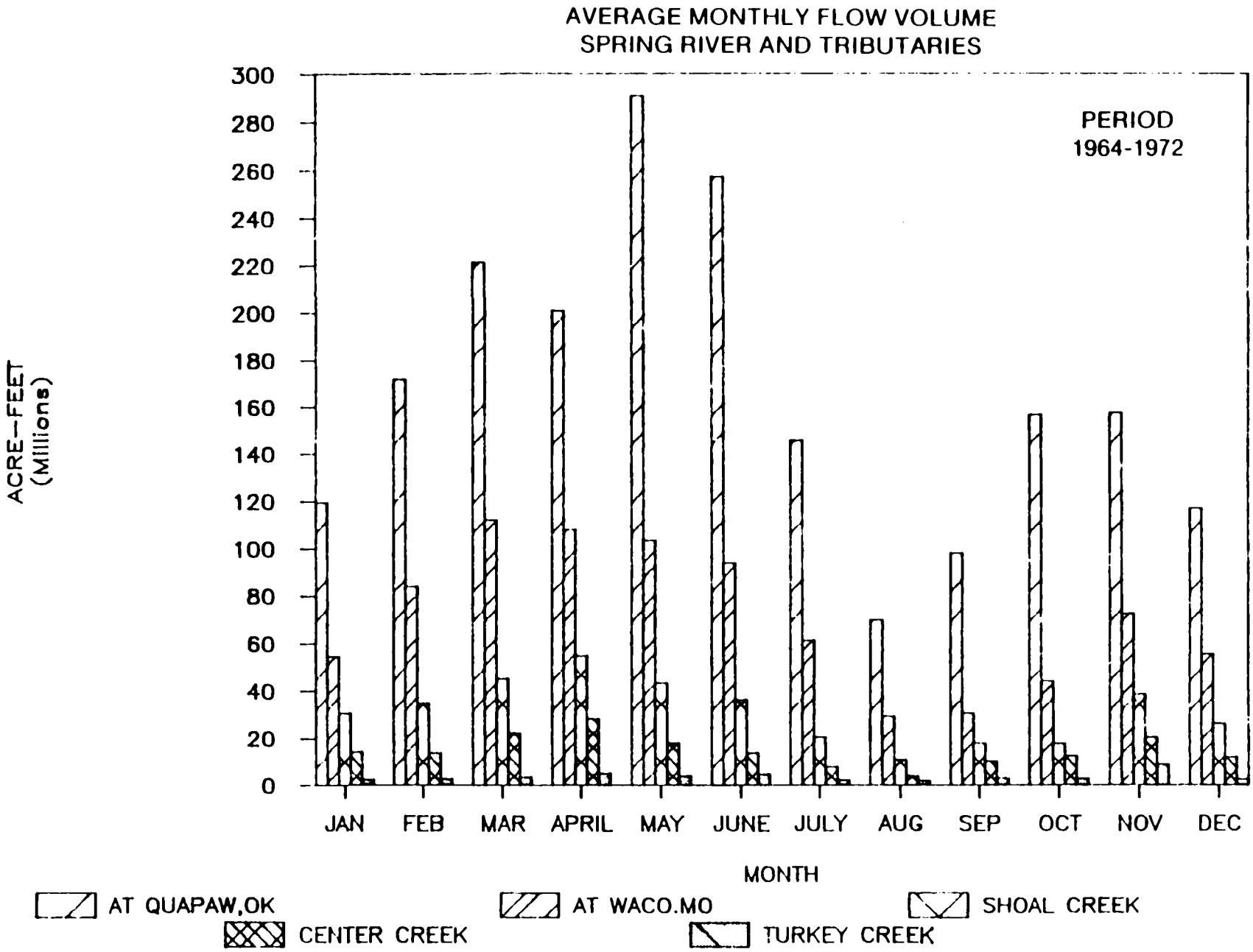
FIGURE 5



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REVIEW OF AVAILABLE WATER QUALITY DATA

Available water quality data for the study area were obtained from the U.S. EPA STORET information system. Three significant periods of data collection were found. These were a collection of data taken in July 1969; a collection of data taken in June and August 1981, and March 1982; and a collection of data taken generally each month during the years 1967 through 1984.

1969 SERIES

No published discussion of the 1969 series of data has been found. The water quality samples were taken daily between July 23 and July 29 at discrete sampling stations around the study area. Table 3 lists the flow and the concentrations of selected parameters found in these water samples. Figure 6 shows the general location of the stations with respect to the study area and the average mass loadings of sulfate and zinc over the 7-day period at stations where data were complete. Average mass loadings are reported only when five or more measurements were reported at a particular station where data were complete. The exact locations of the sampling points has not been determined due to incomplete documentation.

Average mass loading values were evaluated from data collected during the week of July 23 to 26 in 1969. These data were collected from the Spring River and associated tributaries. The initial sampling began near Waco, Missouri, and ended near Quapaw, Oklahoma. Sampling parameters used for the average mass loading included total sulfate and dissolved zinc. These sulfate loading rate values ranged from 27 gm/sec at Shawnee Creek to 1,069 gm/sec at Quapaw. The zinc values ranged from 0.6 gm/sec at Shoal Creek to 19 gm/sec at Willow Creek.

Shown in Figure 6 are the relative localities along the Spring River where the average mass loading values for sulfate and zinc were calculated based on these data. Summarizing Figure 6, a general trend of increasing sulfate and zinc values is present downstream on the Spring River from Waco, Missouri, to the Kansas-Oklahoma border.

The localities with significantly high average mass loads within the Galena and Baxter Springs subsites, respectively, were Short Creek below Galena with a sulfate loading rate of 100 gm/sec and a zinc loading rate of 16 gm/sec, and Willow Creek near Baxter Springs with a sulfate loading rate of 402 gm/sec and a zinc loading rate of 19 gm/sec. Localities

Table 3
1969 WATER QUALITY DATA BY LOCATION

SPRING RIVER NEAR WACO, MISSOURI

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	146	131	129	123	115	108	102
Total Hardness	168	172	184	184	184	176	184
Total Sulfate	14	15	12	13	14	8	15
Dissolved Zinc	0	60	0	0	0	0	0
Total Manganese	80	190	60	NS	NS	NS	NS
Dissolved Lead	90	NS	NS	NS	NS	NS	NS
Total Iron	410	600	310	390	460	410	400

COW CREEK NEAR LAWTON, MISSOURI

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	13	13	13	10	10	10	10
Total Hardness	445	496	476	516	472	408	380
Total Sulfate	444	972	492	536	496	416	200

SPRING RIVER NEAR CRESTLINE, MISSOURI

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	227	214	208	198	184	169	161
Total Hardness	188	216	204	220	200	196	200
Total Sulfate	46	25	62	81	58	51	71

Notes: Units of Measurement
Flow--cfs
Hardness--mg/l as $CaCO_3$
Sulfate--mg/l
Zinc--µg/l
Manganese--µg/l
Lead--µg/l
Iron--µg/l

NS and O represent not analyzed or below detection limits, respectively.

Table 3
(continued)

CENTER CREEK NEAR SMITHFIELD, MISSOURI

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	83	81	79	76	71	73	70
Total Hardness	228	220	244	236	236	228	232
Total Sulfate	98	84	100	85	89	86	91
Dissolved Zinc	450	270	420	540	450	360	600
Total Manganese	170	220	160	NS	NS	NS	NS
Dissolved Lead	10	NS	NS	0	NS	NS	0
Total Iron	110	140	100	70	130	270	80

SPRING RIVER ABOVE TURKEY CREEK

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	267	254	247	235	218	200	189
Total Hardness	200	196	200	216	212	208	208
Total Sulfate	69	57	61	72	76	63	70
Dissolved Zinc	NS	NS	NS	NS	NS	NS	NS

TURKEY CREEK NEAR JOPLIN, MISSOURI

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	18	22	17	16	14	15	15
Total Hardness	288	272	252	272	300	288	280
Total Sulfate	133	122	112	121	124	131	129
Dissolved Zinc	NS	NS	NS	NS	NS	90	NS
Total Manganese	220	440	190	NS	NS	NS	350
Total Iron	370	440	300	330	300	310	480

Notes: Units of Measurement
Flow--cfs
Hardness--mg/l as $CaCO_3$
Sulfate--mg/l
Zinc--µg/l
Manganese--µg/l
Lead--µg/l
Iron--µg/l

NS and 0 represent not analyzed or below detection limits, respectively.

Table 3
(continued)

SPRING RIVER RIGHT ABOVE GULF CHEMICAL

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	293	280	272	259	240	220	208
Total Hardness	232	208	212	212	220	216	204
Total Sulfate	111	66	70	70	79	80	72
Dissolved Zinc	NS	NS	NS	NS	NS	NS	NS

SPRING RIVER RIGHT BELOW GULF CHEMICAL

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	330	319	308	294	272	248	235
Total Hardness	224	212	224	232	220	216	236
Total Sulfate	83	65	93	84	86	74	87
Dissolved Zinc	NS	NS	NS	NS	NS	NS	NS

SHORT CREEK ABOVE GALENA, KANSAS

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	1	1	1	2	2	1	1
Total Hardness	1,040	1,000	1,010	1,110	1,090	1,240	1,290
Total Sulfate	1,040	924	948	1,040	1,044	1,164	1,228
Dissolved Zinc	26,000	26,000	23,000	27,000	26,000	29,000	31,000
Total Manganese	5,400	5,300	4,900	NS	NS	NS	6,100
Dissolved Lead	40	NS	NS	0	NS	NS	0
Total Iron	3,000	4,100	4,500	5,500	4,800	5,300	4,900

Notes: Units of Measurement
- Flow--cfs
- Hardness--mg/l as $CaCO_3$
- Sulfate--mg/l
- Zinc--µg/l
- Manganese--µg/l
- Lead--µg/l
- Iron--µg/l

NS and 0 represent not analyzed or below detection limits, respectively.

Table 3
(continued)

SHORT CREEK BELOW GALENA, KANSAS

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	5	5	4	4	4	4	4
Total Hardness	380	570	472	460	470	480	470
Total Sulfate	776	748	804	784	840	908	920
Dissolved Zinc	135,000	159,000	141,000	123,000	138,000	159,000	162,000
Total Manganese	3,700	4,000	4,000	NS	NS	NS	2,900
Dissolved Lead	530	NS	NS	430	NS	NS	390
Total Iron	1,300	530	720	310	440	790	670

SHAWNEE CREEK NEAR GULF CHEMICAL

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	15	15	15	14	13	11	11
Total Hardness	188	196	208	200	212	208	204
Total Sulfate	71	59	72	73	75	79	78
Dissolved Zinc	NS	NS	NS	NS	NS	NS	NS

SPRING RIVER NEAR RIVERTON, KANSAS

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	349	338	327	311	288	263	249
Total Hardness	121	216	224	200	196	208	212
Total Sulfate	85	75	95	77	65	79	73
Dissolved Zinc	NS	NS	NS	NS	NS	NS	NS

Notes: Units of Measurement
Flow--cfs
Hardness--mg/l as $CaCO_3$
Sulfate--mg/l
Zinc--µg/l
Manganese--µg/l
Lead--µg/l
Iron--µg/l

NS and 0 represent not analyzed or below detection limits, respectively.

Table 3
(continued)

SHOAL CREEK NEAR GALENA, KANSAS

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	194	194	194	188	182	170	167
Total Hardness	132	148	152	152	148	156	160
Total Sulfate	11	14	19	9	12	7	11
Dissolved Zinc	60	300	120	60	60	60	90
Total Manganese	190	230	80	NS	NS	NS	80
Dissolved Lead	20	NS	NS	70	NS	NS	40
Total Iron	330	550	310	210	220	210	280

WILLOW CREEK NEAR BAXTER SPRINGS, KANSAS

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	7	7	6	6	6	7	6
Total Hardness	1,660	1,080	1,710	1,630	1,630	1,550	1,650
Total Sulfate	2,252	2,190	2,170	2,120	2,270	2,150	2,320
Dissolved Zinc	105,000	105,000	105,000	102,000	105,000	105,000	108,000
Total Manganese	2,700	2,700	2,700	2,700	NS	NS	2,500
Dissolved Lead	1,200	NS	NS	950	NS	NS	NS
Total Iron	134,000	146,000	110,000	126,000	140,000	140,000	146,000

Notes: Units of Measurement
Flow--cfs
Hardness--mg/l as $CaCO_3$
Sulfate--mg/l
Zinc--µg/l
Manganese--µg/l
Lead--µg/l
Iron--µg/l

NS and 0 represent not analyzed or below detection limits, respectively.

Table 3
(continued)

SPRING RIVER NEAR QUAPAW, OKLAHOMA

Measurement	Sampling Date 7/23	7/24	7/25	7/26	7/27	7/28	7/29
Flow	480	471	454	432	400	362	343
Total Hardness	220	212	220	208	216	220	228
Total Sulfate	86	77	85	91	92	95	110
Dissolved Zinc	540	600	750	720	1,000	690	1,200
Total Manganese	230	470	350	NS	NS	NS	500
Dissolved Lead	0	NS	NS	0	NS	NS	70
Total Iron	1,000	870	980	910	560	550	660

Notes: Units of Measurement
Flow--cfs
Hardness--mg/l as $CaCO_3$
Sulfate--mg/l
Zinc--µg/l
Manganese--µg/l
Lead--µg/l
Iron--µg/l

NS and 0 represent not analyzed or below detection limits, respectively.

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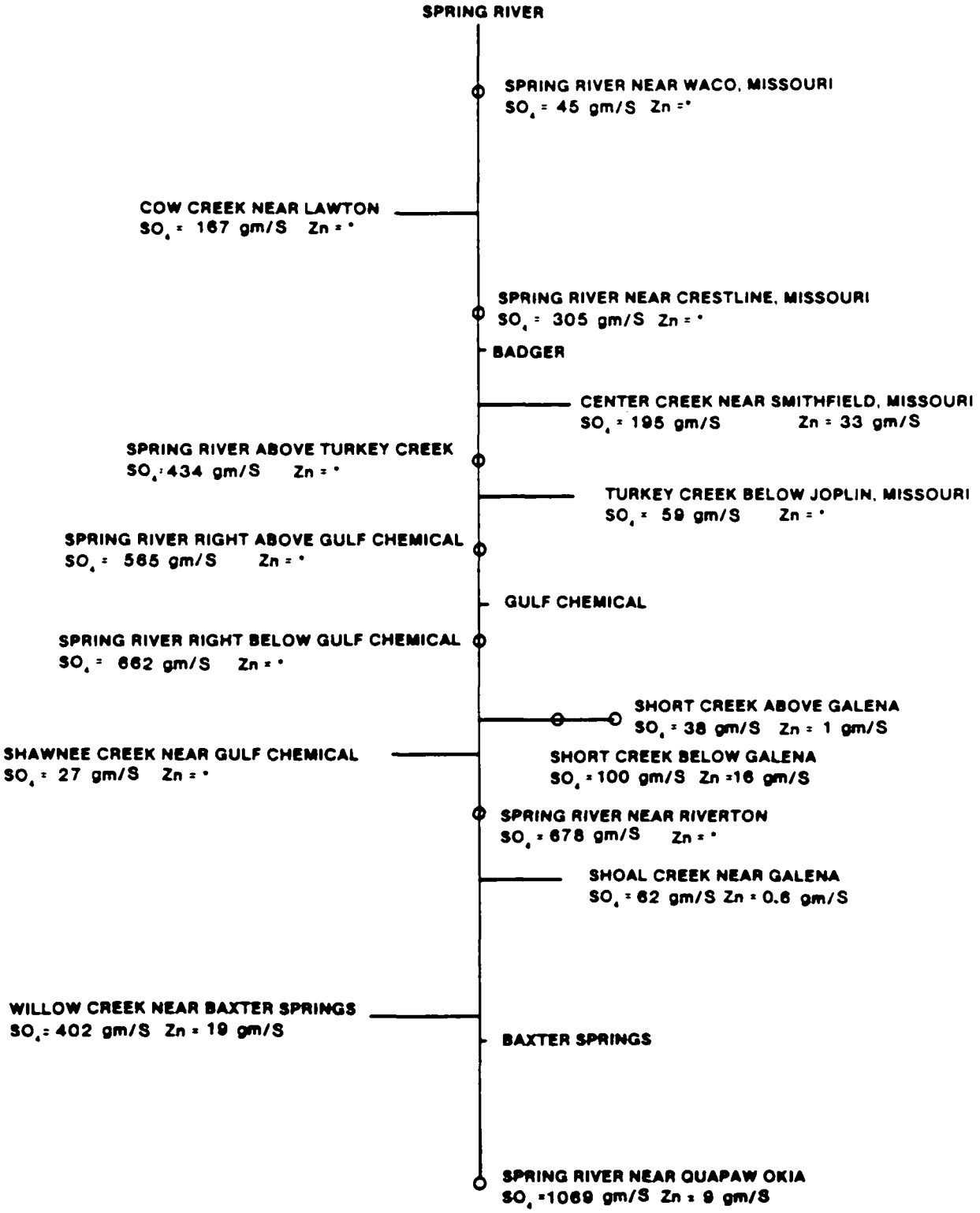

* Dissolved zinc data not availabe for most sampling dates, therefore the average values are not given.

FIGURE 6
AVERAGE MASS LOADING VALUES
SPRING RIVER AND MAJOR TRIBUTARIES
SOUTHEAST KANSAS
1969 DATA
CHEROKEE COUNTY SITE

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outside these two subsites with significantly high average mass loading values were Center Creek near Smithfield, Missouri, to the north of the Galena subsite, and the Spring River downstream of the Cherokee County site. The sulfate and zinc loading values at Center Creek were 195 gm/sec and 33 gm/sec, respectively. South of the site, the Spring River near Quapaw, Oklahoma, had high loadings with sulfate and zinc values being 1,069 gm/sec and 9 gm/sec, respectively.

1981-1982 SERIES

The observations and discussion of the 1981-1982 data series were reported by Spruill (1984)[1]. Spruill observed the increase in stream base flow associated with abandoned mines and chat piles around the study area. He also observed the increase in trace metal concentrations associated with lead-zinc mine drainage and the increase in these metal concentrations, which reflect groundwater inflows from the mined areas.

1967 THROUGH 1984 SERIES

No published discussion of the water quality measurements taken during the period 1967 through 1984 has been located. Flow measurements and water quality samples were taken at six locations presumably as a part of the general USGS water quality network or some state or federal agency study. The six sampling locations for the 1967-84 data set were:

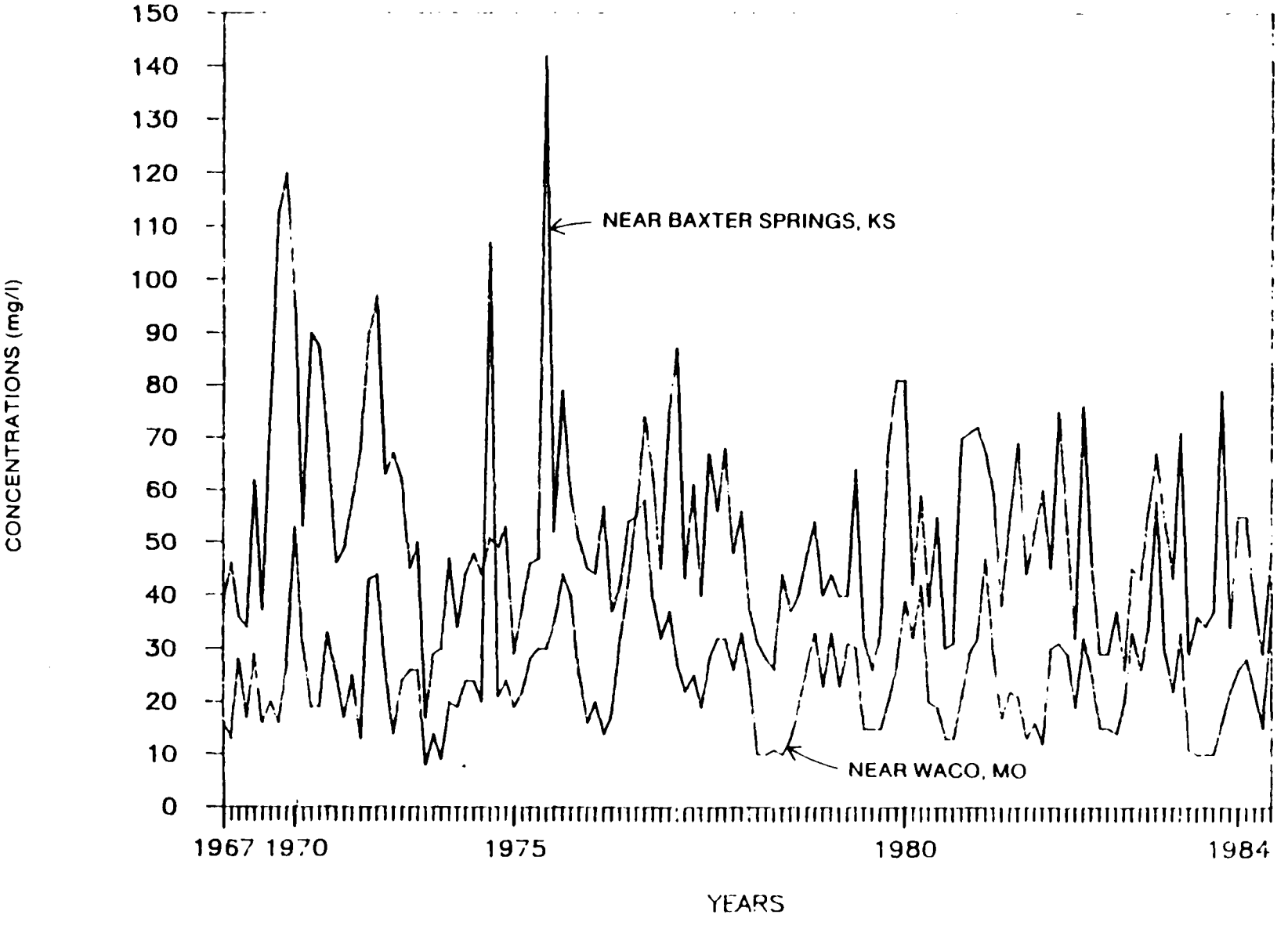
- Spring River near Waco, MO
- Center Creek near Smithfield, MO
- Turkey Creek near Joplin, MO
- Shoal Creek near Galena, KS
- Spring River near Baxter Springs, KS
- Neosha River near Chetopa, KS

Due to the lack of documentation, the exact location of some of the water quality stations has not been determined.

The number of water quality parameters analyzed in the samples for this study increased over the period. General water chemistry and nutrient data were collected for the first 3 to 6 years and pesticides and metals were added later. Sulfate concentration, which could be an indicator of acid mine drainage, was measured at the two Spring River stations over the entire period of record. Figure 7 is a

[1] Spruill, Timothy B., Assessment of Water Resources in Lead-Zinc Mined Areas in Cherokee County, Kansas, and Adjacent Areas, USGS Open-File Report 84-439.

FIGURE 7
ANNUAL VARIATION IN TOTAL SULFATE
SPRING RIVER
JULY 1967 THROUGH FEBRUARY 1984



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plot of the sulfate concentration recorded at these two stations over the 1967-1984 period. This plot shows the variation in sulfate concentrations measured over the period of record and a consistent increase in sulfate concentration between the Baxter Springs and Waco locations. The plots indicate neither a general upward nor downward trend in sulfate concentration over the 17-year period. Because the flows measured at Baxter Springs were consistently higher than those measured at Waco, the relationship between mass loadings of sulfate at these two locations will be similar to the relationship between concentrations recorded at these stations (i.e., the mass loading at Baxter Springs will be higher than that at Waco).

The relationship between the sulfate concentration and river flow rate at the stations on the day samples were taken is shown in Figures 8 and 9. These plots show no discernible relationship between sulfate concentration and flow at the lower discharges. The downward trend in concentrations with increasing discharge indicates a dilution effect during larger flow events.

Further analysis of the 1967-1984 data is possible as may be warranted. However, additional information on sampling locations, field and lab methods, and quality control protocol will be obtained first. Concentrations of some metals were measured at these stations, although not over the entire 17-year period, so further analyses may benefit the RI/FS studies. The first three station locations listed are outside the Cherokee County study area, so water quality measurements at these stations represent waters entering the study area. The water quality measurements taken at the Baxter Springs gage are for surface water leaving the study area, and the Neosha River station is unrelated to the Cherokee County Site. Therefore, of the six sampling locations in this data set, only one is within the site.

FIGURE 8
TOTAL SULFATE VS. FLOW
SPRING RIVER AT WACO, MO
1969-1984

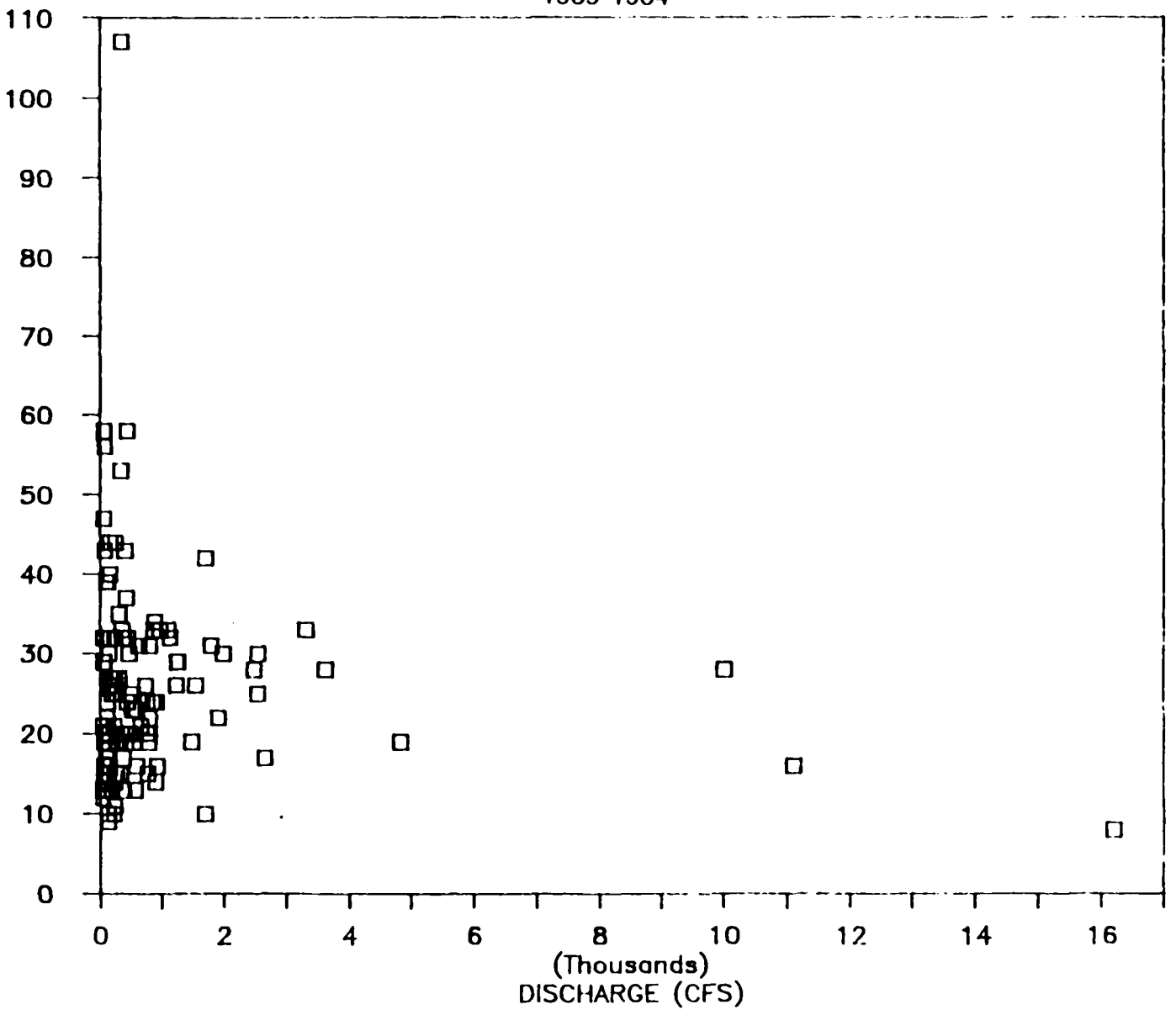

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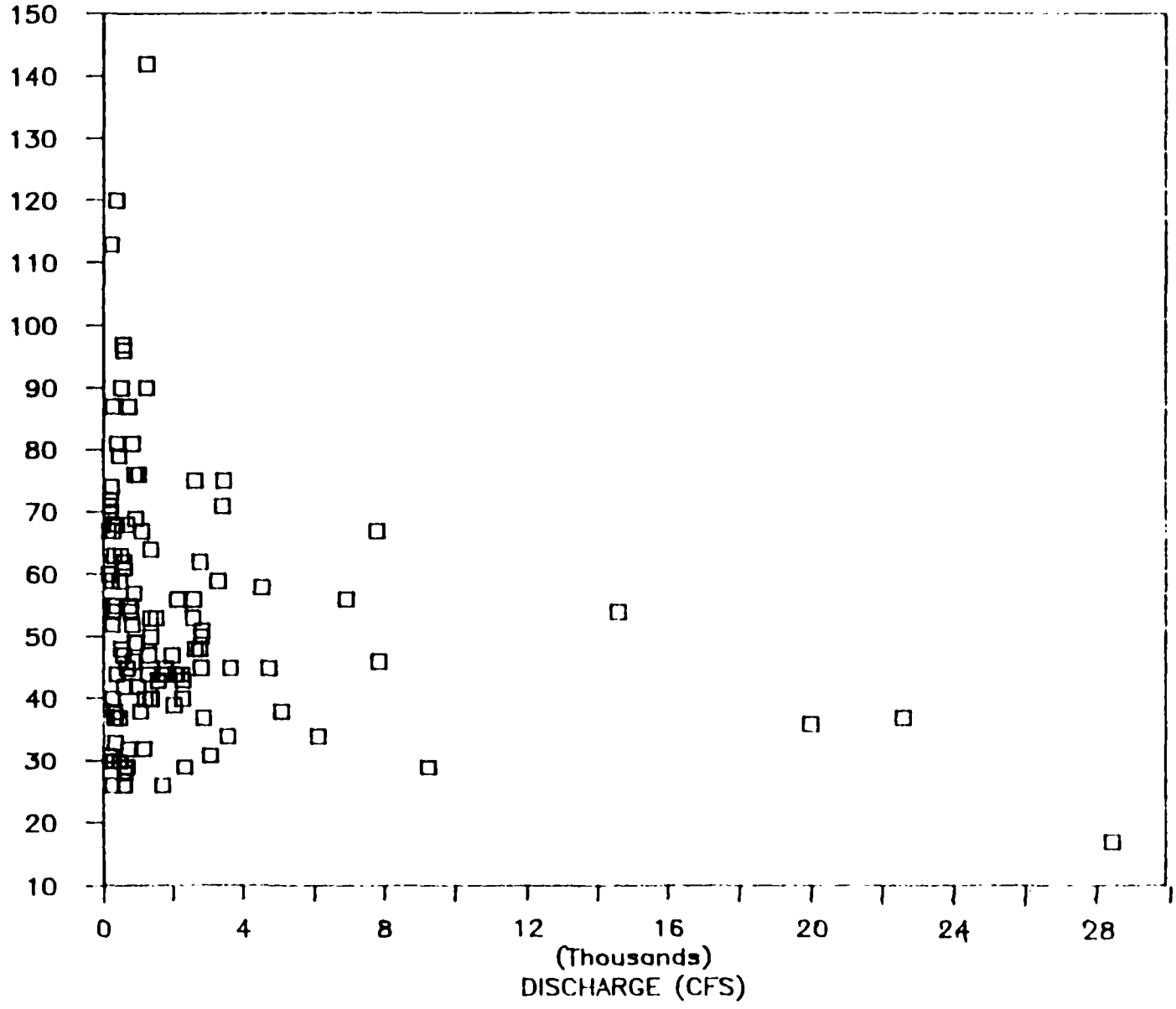
FIGURE 9
TOTAL SULFATE VS. FLOW
SPRING RIVER AT BAXTER SPRINGS' KANSAS
1969-1984



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